

CROSSPOINT RESISTOR MEMORY DEVICE WITH BACK-TO-BACK SCHOTTKY DIODES

RELATED APPLICATIONS

[0001] This application is a Continuation-in-Part of a pending patent application entitled, MSM BINARY SWITCH MEMORY DEVICE, invented by Sheng Teng Hsu et al., Ser. No. 11/184,660, filed Jul. 18, 2005.

[0002] This application is a Continuation-in-Part of a pending patent application entitled, METAL/ZnOx/METAL CURRENT LIMITER, invented by Tingkai Li et al., Ser. No. 11/216,398, filed Aug. 31, 2005.

[0003] The above-mentioned applications are both expressly incorporated herein by reference, and both claim priority under 35 U.S.C. §120.

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] This invention generally relates to an integrated circuit (IC) fabrication process and, more particularly, to a crosspoint resistor memory with an MSM device that acts as a back-to-back Schottky diode.

[0006] 2. Description of the Related Art

[0007] A cross-point memory array is a matrix of memory elements, with electrical contacts arranged along x-axes (i.e., word lines) and along y-axes (i.e., bit lines). In some aspects, a digital value is stored as a memory resistance (high or low). The memory state of a memory cell can be read by supplying a voltage to the word line connected to the selected memory element. The resistance or memory state can be read as an output voltage of the bit line connected to the selected memory cell.

[0008] Cross-point resistor memory arrays are prone to read disturbance problems. As part of the read operation, electric current flows from a selected word line, through a selected memory cell, to a bit line. However, current also flows into unselected word lines that happen to cross over the selected bit line. The conduction of current into unselected word lines acts to decrease the output impedance and, hence, reduce the output voltage. To clearly distinguish memory states, the output voltage must be clearly distinguishable.

[0009] The undesired flow of current through a resistance memory cell can be addressed through the use of series-connected diodes, since reverse biased diodes are poor conductors. However, this same feature makes a one-diode/one resistor (1D1R) memory difficult to program. Programming voltages cannot be used that reverse bias the diode. Therefore, 1D1R cells are better suited for unipolar programming. Further, diodes are preferable formed from single crystal silicon, for optimal performance. However, large crystal grains are difficult to form using thin-film deposition processes.

[0010] Many cross-point resistor memory array structures have been proposed in attempts to minimize cross-talk problems during read operations in a large area cross-point resistor memory array. IRID memory cell are well suited for a mono-polarity programming memory array. However, good diodes can only be fabricated on single crystal silicon.

For multi-layer three-dimensional arrays, the upper layer of a diode is formed by re-crystallization of deposited silicon, and the resulting diode usually exhibits poor electrical properties. In addition, the diode must be formed from a silicon film that is fairly thick.

[0011] Rinerson et al., U.S. Pat. No. 6,753,561, have proposed a memory cell of a metal/insulator/metal (MIM) structure in series with a resistor memory. The MIM device is non-conductive at low biases. When the bias voltage is higher than a certain value, the conductivity drastically increases. This voltage is called either the "current rise-up voltage" or "varistor voltage". The high field generated in response to the MIM high current region is associated with impact ionization. MIM devices are well known to be unstable if subjected to high current density stress. This is due to deep trap states in the insulator and the local avalanche breakdown when a high electric field is applied to the insulator. As a result, the current voltage characteristics are reversible only at relatively low current conditions. Therefore, MIM non-ohmic devices are not suitable for cross-point memory cells, which require a large numbers of programming operations. In addition, Rinerson does not teach specific MIM materials, or how a MIM device is fabricated.

SUMMARY OF THE INVENTION

[0012] Described herein is a back-to-back diode device that permits current flow in both forward and reverse directions under higher voltage (forward and reverse) bias conditions, but blocks current in under lower voltage bias conditions. The current limiter can be added to a resistance memory cell, to permit high voltage bipolar programming, without the penalty of flowing current into unselected word lines during lower voltage read operations.

[0013] Many conventional cross-point resistor memory arrays suffer from read disturbance problems, as electric current flows from a selected word line, through a selected memory cell to a bit line, and then into unselected word lines which cross over the bit line. A cross-point array made with a current limiter in the memory cells minimizes the current flow into the unselected word lines, maximizing the output (read) voltage.

[0014] A metal/semiconductor/metal (MSM) back-to-back Schottky barrier device exhibits a symmetrical non-ohmic property with respect to both positive and negative bias voltages. This device can be used as memory cell current limiter to resistor cross-point memory array. Since the conductivity of the semiconductor is high, and the capture cross-section of trap state is small, the device is stable operating at high fields. The current density of MSM device can be several orders of magnitude higher than that of MIM devices.

[0015] Accordingly, a method is provided for forming a MSM back-to-back Schottky diode. The method comprises: providing a substrate; forming a metal bottom electrode overlying the substrate, having a first work function; forming a semiconductor layer overlying the metal bottom electrode, having a second work function, less than the first work function; and, forming a metal top electrode overlying the semiconductor layer, having a third work function, greater than the second work function.